International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249–6890; ISSN (E): 2249–8001
Vol. 10, Issue 2, Apr 2020, 1013–1020

MORPHOLOGICAL CHARACTERIZATION OF FRICTION WELDED ALUMINIUM ALLOY

R. PRAVEEN KUMAR[1*], R. RAJAVEL[2] & G. NAVANEETHAKRISHNAN[3]

[1,2]*Department of Mechanical Engineering, Academy of Maritime Education and Training, Chennai, India*

[3]*Department of Mechanical Engineering, K. Ramakrishnan College of Technology, Trichy, India*

ABSTRACT

In the modern developments to increase the methodologies in liquid state welding process, a new concern about the solid state welding shall be looked after as a change in scenario as it may be suiting in many places as a replacement because of its improved characteristics over the case compared to liquid state welding process. Here in our work, we take the case of friction welding process for joining various combination of the following aluminium alloys 5083, 6061, 7075 were taken for consideration and the parameters which were used are spindle speed, friction pressure, friction time, forging pressure, forging time. Once the welding process is completed the Scanning Electron Microscope (SEM) is used to examine the interface region of the weld specimen to determine the microstructure changes. In order to calculate the mechanical properties, the micro hardness test and tensile test are carried out in the welded specimen and the weldability of these alloy in solid state welding process was done friction welding method and the characteristics were studied by Scanning Electron Microscope (SEM) analysis

KEYWORDS: Friction Welding; SEM & Aluminium Alloy

Received: Mar 07, 2020; **Accepted**: Mar 27, 2020; **Published**: Apr 03, 2020; **Paper Id.**: IJMPERDAPR202098

Original Article

INTRODUCTION

Friction welding is one of the solid-state welding process which is done by generation of the heat between the two metals which are to be welded by friction between the ends [1]. The metals which are to be welded are axially aligned in which one part is being rotated at very high speeds whereas the other part is kept stationery but kept pressed tightly against the rotating part [2]. The friction which is generated by the moving parts rapidly increases the temperature at both the ends of the metals [3-4]. The rotating part is stopped abruptly and the friction pressure which is the pressure applied on the stationary part is increased when the joining between the two metals occurs [5-8].

As it is known, most of the industries are adopting friction welding methodology increasingly [9-10], in which the heat that is generated by converting the mechanical energy to thermal energy [11-13] along the interface layer between the work pieces while the moving part rotates under the influence of pressure applied by the stationary part [14-15]. By adopting the friction welding process methodology, we will be able to join any form of materials like ferrous and non-ferrous alloys [16] or circular and non-circular cross section materials or two different materials have varying mechanical and thermal properties [17]. The metallic bonding between the materials used in the process of friction welding process which falls under the category of solid-state welding process is achieved at temperatures which are slightly lower than the base metals melting point [18-19]. The major parameters which are to be considered in the friction welding process are friction time, friction pressure, forging

time, forging pressure and rotation speed [20]. Properties of glass fiber reinforced composites have been discussed in detail [21]. MIG welded joints were experimentally examined [22].

MATERIALS AND METHODS

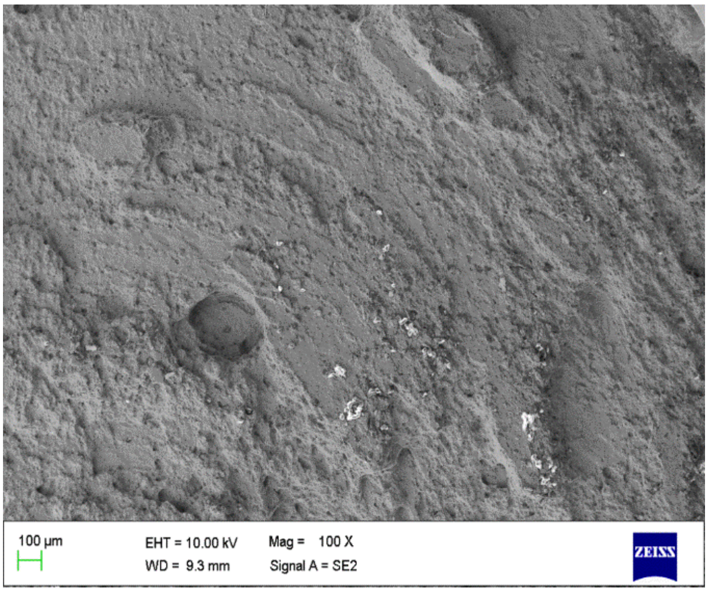
In this work, we have taken three different material namely aluminium alloys 5083, 6061, 7075 for considerations and it was joined by using friction welding method and various combinations of these alloys were joined by using this method and the samples were taken for examination like making Al5083+Al7075, Al5083+Al6061 and Al6061+Al7075 and these combinations were welded in various welding parameters like spindle speed, friction pressure, friction time, forging pressure, forging time were considered by varying the parameters of the welding methodology. In this work, the spindle speed was varied for various stages like 800 rpm, 900 rpm, 1000 rpm and in these varying speeds, the weld samples were taken and they were taken and tested for the various mechanical properties such as percentage of elongation test, hardness test, yield strength test and tensile strength test were conducted on the welded specimens. Likewise, these welded joints were taken and tested in Scanning Electron Microscope (SEM). These SEM tests are conducted and the test results were analysed in detail.

RESULTS AND DISCUSSIONS

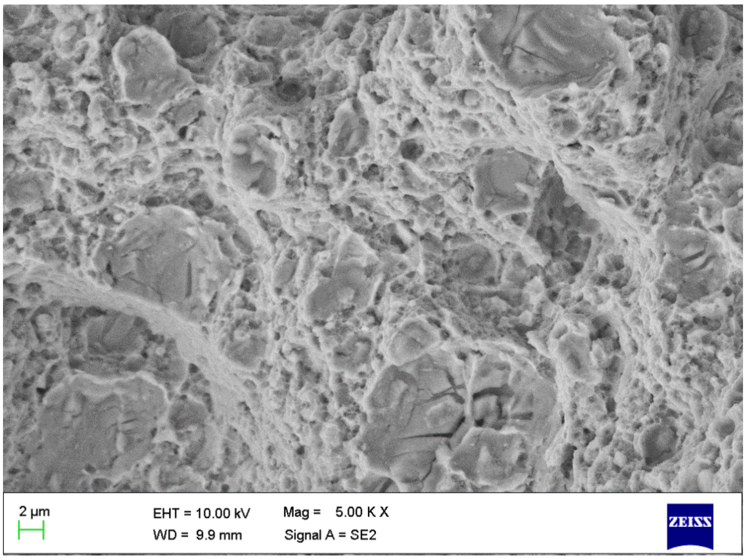
The microstructure photos are given here are the interface layer of the joints of the parent metal which they belong to which consists of the austenitic grain structure. The microphotographs clearly depict that the aluminium alloy has been deformed greatly with the elongated grains that are clearly refined near the weld interface layers. There is a slight deformation in the stainless steel and a partial transformation near the faying surface which occurs from the austenite to martensite that owes to the hard upsetting formation. The hard inter diffused constituent elements pertaining to both the base materials along the weld interface where the formation of intermetallic compounds such as Fe Al and Fe_3Al occurs. It is highly recommended to carry out the imaging process for the conventional SEM under vacuum since the gas atmosphere will start to spread very rapidly and it also attenuates the electron beams too. It is needed to dry or freeze cryogenically the samples that may produce a considerable amount of vapour for example biologically wet samples or the oil-bearing rocks. In the process of conventional high-vacuum SEM is not possible to be carried out for the process which involves the phase transactions such as liquid transport, solid-air-gas systems, chemical reactions, drying of the adhesives or melting of the alloys. The chamber of the environmental SEM (ESEM) is completely evacuated of the air whereas while reaching the saturation pressure water vapours are retained, and the value of the residual pressure will remain very high which makes possible for the volatile substances or the samples containing water could be analyzed. The observations of living insects are even made possible by utilization of this ESEM.

This scanning electron microscope is not a conventional camera also the detector could not be able to continuously image-forming like a CCD array or film. The fineness of the lens or mirror or detector array resolution and the diffraction limit could not restrict the resolution as like in the case of optical systems.

Micro-structure of aluminium Al 5083+Al 6061 at 800rpm



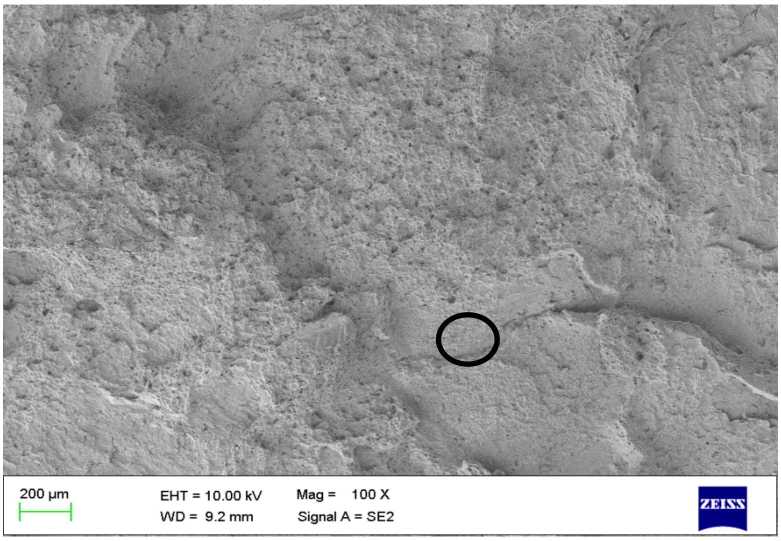
- **inclusion of slag are higher in all section**
- **Boundary layers are visible**
- **Crack Inclusion are clearly visible**



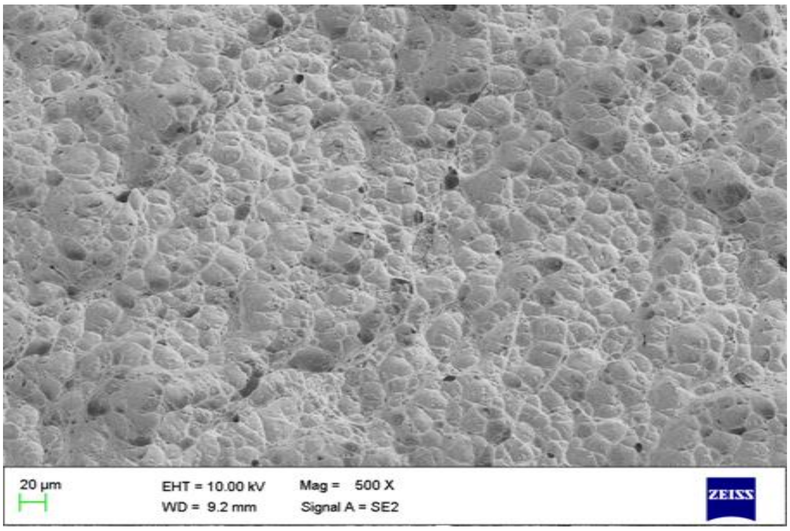
- Distribution of weld is not so even
- Overall weld looks dull
- Tiny particles are bonded well
- Fusion of welding is good

Figure 1: Micro Structure Images of Aluminium 5083+6061 at 800 rpm.

Micro- structure of aluminium Al 5083+Al 7075 at 900 RPM



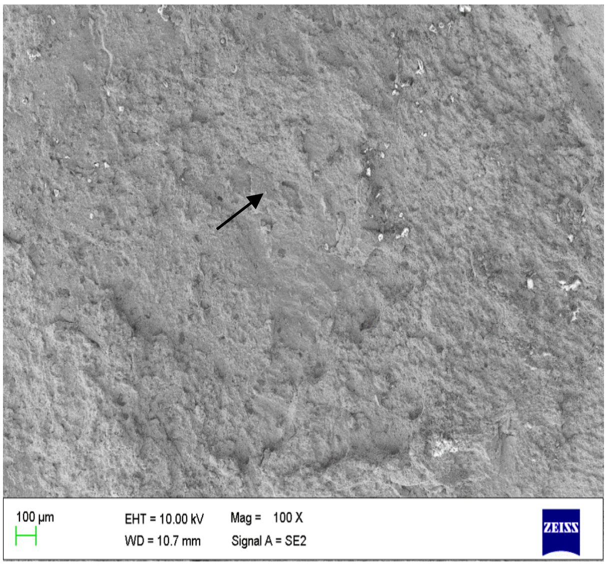
- Boundary layers are clearly visible
- Slag formation is very low
- Cracks are visible
- Overall weld looks smooth



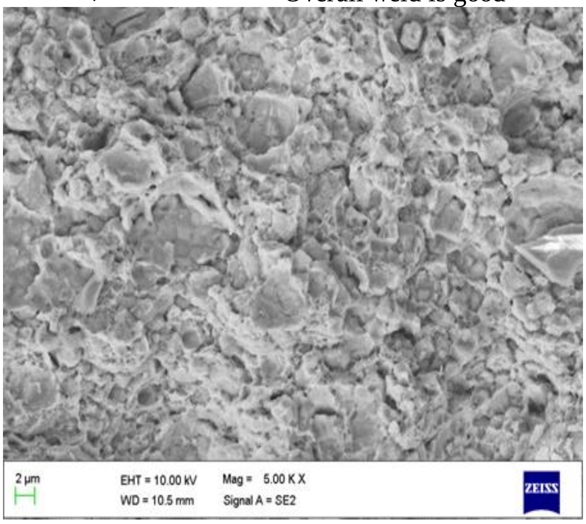
- Fusion of welding is very good
- Boundary layers are clearly visible
- Bonding of tiny particles are good

Figure 2: Micro Structure Images of Aluminium 5083+7075 at 900 rpm.

Micro- Structure of Aluminium Al 6061+Al 7075 at 1000 rpm



- Slag inclusion in high
- Visible weld is good
- Overall weld is good



- Distribution of weld is even
- Boundary layers are visible
- Structural bond is very good

Figure 3: Micro Structure Images of aluminium 6061+7075 at 1000rpm.

CONCLUSIONS

In this investigation process of friction welding, it is found that the combination of Al 5083 & Al 6061 with rotation speed of 1000 rpm from the microstructure inference the distribution of alloy was found to be even and the corresponding hardness value was found to be 164 HV which is maximum in the all possible combinations. The hardness value for the Al 5083 & Al 7075 at 900 rpm was recorded as 151 HV and the hardness value for Al 6061 & Al 7075 at 800 rpm is found to be 160 HV. During the process of friction welding, we need to properly select the speed as it plays a major role in the hardness value of the welded sample.

REFERENCES

1. School of Mechanical and Automotive Engineering, South China University of Technology Guangzhou 510640, China, Dissimilar friction stir welding between 5052 aluminum alloy and AZ31 magnesium alloy
2. Wang Xunhonga,Wang Kuaishe a,b, Microstructure and properties of friction stir butt-welded AZ31 magnesium alloy
3. H. WATANABE, T. MUKAI, K. ISHIKAWA, Differential speed rolling of an AZ31 magnesium alloy and the resultingmechanical poperties
4. S.D. Meshram, T. Mohandas, G. Madhusudhan Reddy. Friction welding of dissimilar pure metals
5. A. A. McLean, G. L. F. Powell, I. H. Brown and V. M. Linton, Friction stir welding of magnesium alloy AZ31B to aluminium alloy 5083
6. M. B. Uday, M. N. Ahmad Fauzi, H. Zuhailawati and A. B. Ismail, Advances in friction welding process: a review
7. M. Srinivasan a, C. Loganathan b, V. Balasubramanian c, Q.B. Nguyen d, M. Gupta d, R. Narayanasamy e, Feasibility of joining AZ31B magnesium metal matrix composite by friction welding
8. Alavala, CHENNAKESAVA R. "FEM analysis of single point incremental forming process and validation with grid-based experimental deformation analysis." International Journal of Mechanical Engineering 5.5 (2016): 1-6.
9. J. A. esparza, W. C. davis, E. A. trillo, L. E. murr Department of Metallurgical and Materials Engineering, The University of Texas at El Paso, El Paso,, Friction-stir welding of magnesium alloy AZ31B
10. G. Liu, L.E. Murr, C-S. Niou, J.C. McClure, and F.R. Vega Department of Metallurgical and Materials Engineering, Microstructural Aspects Of The Friction-Stir Welding Of 6061-T6 Aluminum
11. Yunus, M. O. H. A. M. M. E. D., and MOHAMMAD S. Alsoufi. "A statistical analysis of joint strength of dissimilar aluminium alloys formed by friction stir welding using taguchi design approach, anova for the optimization of process parameters." IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET) 3.7 (2015): 63-70.
12. M.W. mahoney, C.G. rhodes, J.G. flintoff, R.A. spurling, and W.H. BINGEL, Properties of Friction-Stir Welded 7075 T651 Aluminum
13. R. Panicker a, A.H. Chokshi a R.K. Mishra b, R. Verma b, P.E. Krajewski, Microstructural evolution and grain boundary sliding in a superplastic magnesium AZ31 alloy
14. I . shigematsu, Y.-J. kwon, K. suzuki, T. imai, N. saito, Joining of 5083 and 6061 aluminum alloys by friction stir Welding
15. A.C. Somasekharan, L.E. Murr, Microstructures in friction-stir welded dissimilar magnesium alloys and magnesium alloys to 6061-T6 aluminum alloy
16. S.Rajakumar, C. Muralidharan, V. Balasubramanian. Establishing empirical relationships to predict grain size and tensile strength of friction stir welded AA 6061-T6 aluminium alloy joints
17. M. Peel, A. Steuwer, M. Preuss, P.J. Withers, Microstructure, mechanical properties and residual stresses as a function of welding speed in aluminium AA5083 friction stir welds
18. Zhikang Shen, Xinqi Yang, Zhaohua Zhang, Lei Cui, Tielong Li, Microstructure and failure mechanisms of refill friction stir spot welded 7075-T6 aluminum alloy joints
19. Jiuchun Yan, Zhiwu Xu, Zhiyuan Li, Lei Li, Shiqin Yang, Microstructure characteristics and performance of dissimilar welds between magnesium alloy and aluminum formed by friction stirring

20. *REDDY, A. CHENNAKEESAVA. "Low and High Temperature Micromechanical Behavior of BN/3003 Aluminum Alloy Nanocomposites." International Journal of Mechanical Engineering and Technology 6.4 (2017): 27-34.*

21. *[18] Sori Wona,1, Bosung Seoa,1, Jong Min Parka, Hyo Kyu Kima, Kuk Hyun Songb, Seok-Hong Minc, Tae Kwon Hac, Kwangsuk Parka, Corrosion behaviors of friction welded dissimilar aluminum alloys*

22. *Sunggon Lim, Sangshik Kim, Chang-Gil Lee, And Sungjoon Kim, Tensile Behavior of Friction-Stir-Welded Al 6061-T651*

23. *A. Kostka,a R.S. Coelho,a J. dos Santosb and A.R. Pyzall, Microstructure of friction stir welding of aluminium alloy to magnesium alloy*

24. *Alavala, Chennakesava R. "Effect of Temperature, Strain Rate and Coefficient of Friction on Deep Drawing Process of 6061 Aluminum Alloy." International Journal of Mechanical Engineering 5.6 (2016): 11-24.*

25. *R. Praveen Kumar, G. Navaneethakrishnan& K. Umanath (2018) "Experimental Analysis of Glass Fibre – Sisal Reinforced Composite Material", International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) (2018), Vol. 8, Special Issue 7, Oct 2018, 943-951.*

26. *Elzanaty, Hesham. "Effect of different Si content on the mechanical properties in Al-based alloy." International Journal of Research in Engineering & Technology (IMPACT: IJRET) 2.7 (2014): 49-54.*

27. *A.R. Sivaram, M. Jaya kumar, K. Umanath, R. Rajavel, T. Karthikeyan, Experimental study on surface quality of mig welded joints, J. Adv. Res. Dyn. Control Syst. 9 (2017) 925–929*